Micro-computed tomography evaluation of maxillary molars mesiobuccal canal preparation using BioRaCe and AlphaKite rotary NiTi systems

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ABSTRACT

Objective: The aim of this study was to evaluate root canal preparation of two nickel-titanium (NiTi) rotary systems (BioRaCe, FKG, Switzerland and AlphaKite, Komet, Germany) using micro-computed tomography (Micro-CT). **Material and Methods:** A total of 20 maxillary first molars, extracted for periodontal and prosthetic reasons, were divided into two groups (n = 10) and scanned by SkyScan 1172. Root canals were irrigated with 2.5% NaOCl between each file change, the root canal preparation was performed up to instrument 35.04 of both BioRaCe and AlphaKite rotary systems. After root canal preparation, teeth were rescanned by micro-CT. The amount of canal transportation, centering ability of rotary instruments and canal variations were analyzed. **Results:** There was no significant difference in canal transportation between the two rotary systems at any level (p > 0.05). **Conclusion:** BioRaCe and AlphaKite instruments showed minimal canal transportation and good centering ability at all areas of the root canal, with no significant difference between the two systems. Root canal curvature did not seem to influence the results.

Keywords: Endodontics. Canal transportation. Centering ratio. Micro-CT.

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Introduction

Manufacturers of NiTi rotary files continue to design and introduce new systems with different characteristics, such as tip size, taper, cross-section, helical angle, and pitch. These different designs may influence instrument flexibility, cutting efficacy, and torsional resistance and may minimize root canal preparation errors. The design of instrument tip, in particular, has been identified as a potential factor for shaping outcomes;[1,2] with preparation errors being linked to file designs with sharp tips,[1,2] even though any difference in clinical outcomes in regard to design variations appear to be minimal.[3] In vitro tests have only begun to identify the effect of specific designs on shaping outcomes.[4]

In 1999, the Race system (FKG, La Chaux-de-Fonds, Switzerland) became available and was modified in 2009 to BioRace (FKG). The latter has the same physical characteristics of Race instruments with alternating cutting edges to avoid self-threading, non-cutting safety tips, sharp cutting edges with triangular sections, and electro-chemical surface polishing. BioRace differs in regard to instruments taper, sizes, sequence and handle codes. The manufacturer claims that BioRace will produce sufficient apical preparation sizes with less files.

In 2005, the Alpha System (Komet, Lemgo, Germany) was introduced.[5] It consists of three different instrument sequences according to root canal size (small, average and large canals). The basic set consists of five files with tapers ranging from 0.10 to 0.02, and sizes ranging from 20 to 35, with a non-cutting safety tip and a five-edged (pentagon) cross-section. The surface of the file is refined by a special titanium nitride coating that the manufacturer claims to prevent premature blunting of blades. For coronal flaring, an instrument with a 0.10 taper is available with a kite-shaped cross-section. There have been very few studies published on this system.[5,6] The AlphaKite system was subsequently introduced (Komet, Lemgo, Germany) and differs from the Alpha System as all of the instruments have a kite-shaped cross-section, with one cutting angle and three supporting cutting angles. Files can be combined in many different ways to suit the operator's requirements.

Several studies used micro-CT to evaluate root canal anatomy,[7] changes in root canal shape after root canal instrumentation,[8-11] and the effectiveness of re-treatment of canals filled with different filling material. Thus, micro-CT has proved to be a viable accurate method for endodontic research and was used to determine transportation of root canal walls as well as the centering ability of two nickel-titanium rotary files when preparing human root canals.

Material and Methods
Sample selection

A total of 20 maxillary first molars with fully formed apices extracted for periodontal and prosthetic reasons were selected for the study. The study was approved by Human Ethics Committee (#10/033) Otago University (New Zealand). Tissue fragments and calcified debris were removed by scaling, and the teeth were stored in 10% formalin until used.

Specimens were first categorized according to the degree of canal curvature of the mesiobuccal (MB) root. Teeth were radiographed (Intra Prostyle, Planmeca Oy, Helsinki, Finland) in both bucco-lingual and mesio-distal plane. A digital radiographic system (Digora™ Optime, Soredex, Finland) was used to capture the image which was then enlarged to size A4 sheet and printed on white paper. The curvature of the MB root was determined according to the criteria described by Schneider,[12] and classified as either straight curvature (= 5°), moderate curvature (10-20°), or severe curvature (25-70°). Specimens were then divided into two groups of ten, ensuring an even distribution of canal curvatures across both groups.

The MB root was then resected at the furcation level using a water-cooled rotary diamond blade (Gillings-Hamco, Rochester, NY, USA) to approximately 10 mm in length. Custom-made acrylic moulds (Castapress, Vertex-Dental B.V., the Netherlands) of the roots were made to ensure subsequent precise repositioning of specimens into the scanning system, and an adhesive radiopaque grid (x-ray mesh, Hager & Werken GmbH & Co. KG, Germany) was attached to the acrylic to be used as reference guide when comparing pre- and post- instrumentation scans. The MB root was able to be removed from the moulds to facilitate instrumentation.

Root canal preparation

Both groups were randomly assigned for preparation by either BioRace (FKG Dentaire, Switzerland),

or AlphaKite instruments (Komet, Germany). A surgical microscope (Carl Zeiss, Germany) was used to identify canal openings (s). After ensuring straight line access to a canal, the working length (WL) was determined with the aid of ISO 10 stainless steel K-file (Dentsply Maillefer, Ballaigues, Switzerland) placed 1 mm short the length when the file tip was just visible at the apical foramina. An apical glide path was established using ISO 15 stainless steel K-file (Dentsply Maillefer) supplemented with GlydeT File Prep (Dentsply Maillefer, Ballaigues, Switzerland). Each rotary system was used according to the manufacturer's instructions, and in all cases the canal was irrigated with 2.5% NaOCl between each file change. ISO 15 stainless steel K-file was used to recapitulate to full WL before moving to the next file in sequence. All instruments were rotated in a 16:1 speed-reducing handpiece powered by a high torque electric motor (Tecknica/ATR motor, Pistoia, Italy), and the flutes were cleaned from debris after each insertion. Each file was used to prepare five MB roots and was then discarded.

The following rotary sequence was used with Bio-RaCe (BR) at a speed of 500 rpm with a torque value of 1 Ncm.

1. BR0 (25/0.08) with four gentle strokes. Preparation was repeated until approximately 4-6 mm of the coronal part of the canal was prepared.

2. BR1 (15/0.05) with four gentle strokes to the WL. If this instrument did not reach the WL, the instrument was removed and cleaned, and then reinserted into the canal until the WL was achieved.

3. BR2 (25/0.04) and BR3 (25/0.06) as described for BR1.

4. BR3 (35/0.04) for final apical preparation using the same principle as described for BR1-3.

The AlphaKite (AK) sequence was run at a speed of 250 rpm and various torque values.

1. AK (30/0.08) for the upper third of the canal, with torque of 1.2 Ncm.

2. AK (25/0.06) for the upper third of the canal and the initial part of the curve, with torque of 0.7 Ncm.

3. AK (25/0.04) for the middle part and transcending the curve of the canal, with torque of 0.4 Ncm.

4. AK (25/0.02) for the apical region, with torque of 0.3 Ncm. Preparation was enlarged by two sizes to AK (35/0.02), with torque values of 0.4 Ncm for size

30, and 0.7 Ncm for size 35. Apical preparation was enlarged to size 35 to be similar to the final apical size when BioRace instruments were used.

Micro-CT scanning

A SkyScan 1172 scanner (SkyScan N.V., Aartselaar, Belgium), capable of reaching a spatial resolution of 5 μm was used to scan the MB roots. The acrylic moulds ensured exact positioning of samples and pre-instrumentation scans were taken without probing the canals for patency to avoid modifying root canals anatomy. Cross-sectional slices of pre- and post-root canal preparation scans were then reconstructed from the set of the acquired angular projections using a modified Feldkamp cone-beam algorithm (NRecon, Version 1.5.1.4). Scan duration was of approximately 50 minutes and approximately 950 slices were created across the level of each root. Reconstructed cross-sectional slices (1000 x 1000 to 800 x 8000 pixels format, isotropic pixels size between 0.9-35 μm) were stored as TIFF files.

Quantitative image analysis

CT Analyzer software (Version 1.5.0.0, Sky Scan N.V., Aartselaar, Belgium) was used for quantitative assessment of images. Data were arranged into three groups; coronal (levels 10, 9, 8), middle (levels 7, 6, 5, 4), and apical (levels 3, 2, and 1). The amount of canal transportation was determined by measuring the shortest distance from the edge of the uninstrumented canal to the periphery of the root, in both mesial and distal directions, and then comparedwith the same measurement obtained from post-instrumented images The mean centering ratio for each system was calculated at each of the ten levels using Gambill et al[13] methods.

Statistical analysis

Mean scores were calculated for coronal, middle and apical measurements for each root, using Microsoft Office Excel software. Transportation and centering ratio results were statistically analyzed using SPSS for windows (IBM™ SPSS™ Statistics 19, NY). Transportation and centering ratio results were compared between both systems and within each system at coronal, middle and apical levels. An alpha level of p < 0.05 was considered significant.

Intra-examiner reliability was assessed in two different ways using SPSS software [14,15] and by calculating intra-class correlation coefficient (ICC).

Results

Canals shaped by BioRaCe were usually transported towards the inside of the curve in the coronal (total of 7, n = 10) and middle third (total of 6, n = 10) sections of root canals. In the apical third, all canals were transported towards the outside of the curve. There was a statistically significant difference (p < 0.05) in the amount of transportation between coronal and apical levels (Fig 1, Table 1).

In the AlphaKite system, one file separated and the specimen was discarded. Five canals were transported towards the inside of the curve at the coronal and middle levels (n = 9), and eight of the nine canals were transported towards the outside of the curve at the apical level. There was no significant difference in the amount of transportation across three levels (Fig 1, Table 1). Transportation with AlphaKite instruments at coronal and apical levels was smaller than with BioRaCe instruments.

Centering ratio results imply that dentine was removed uniformly on the outer and inner side of the root canal by both instruments (Fig 2).

Intra-examiner reliability

Bland-Altman plots showed that vales were within 0.045 and -0.036 for BioRaCe and 0.097 and -0.107 for AlphaKite with most of the data lying within the limits of agreement. High agreement was also noted for both systems when intraclass correlation coefficient (ICC) and Chronbach's Alpha (BioRaCe: 0.0.995, AlphaKite: 0.965) were used.
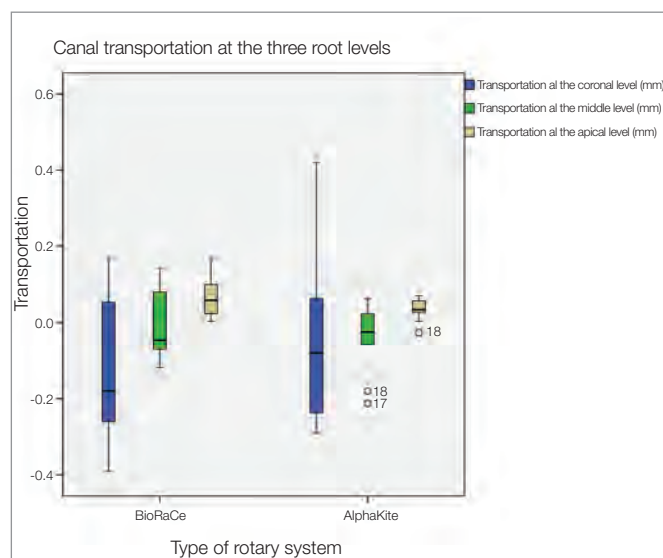

Figure 1. Transportation after root canal preparation with BioRaCe and AlphaKite system in the coronal, middle and apical levels of the root.
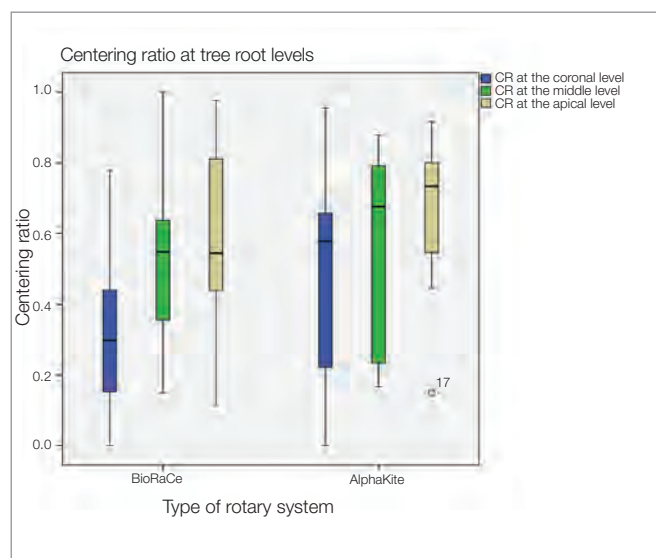

Figure 2. Centering Ratio (CR) across all root levels for BioRaCe and AlphaKite system.

Table 1. Mean transportation (mm) of prepared root canals at root levels.

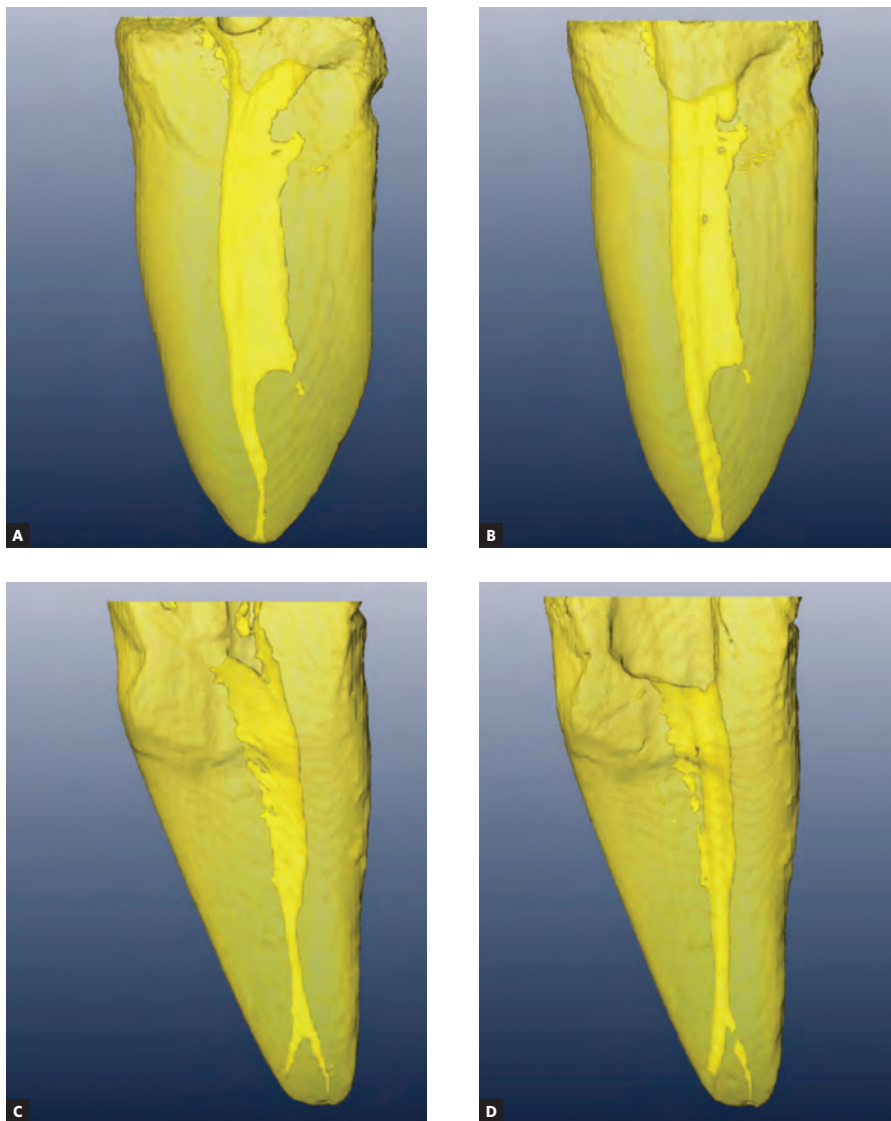| Group	n	Coronal	Middle	Apical
BioRaCe	10	-0.12 ± 0.19	-0.01 ± 0.09	0.06 ± 0.05
AlphaKite	9	-0.05 ± 0.22	-0.04 ± 0.1	0.03 ± 0.03
		(p > 0.05)	(p > 0.05)	(p > 0.05)

Figure 3. Representative image of mesiobuccal root canals pre- and post- root canal preparation with BioRaCe (**A** and **B**) and AlphaKite (**C** and **D**).

Discussion

The present study was designed to determine the amount of canal transportation and the centering ability of two nickel-titanium (NiTi) rotary systems: BioRaCe (FKG, Switzerland) and AlphaKite (Komet, Germany). Many studies have shown the ability of rotary NiTi instruments to remain centered in the canal with a minimal risk of transportation.[16-19] Therefore, it was hypothesized that both BioRaCe and AlphaKite instruments will produce well-centered and tapered preparations with minimal canal transportation.

The canals were evaluated using high-resolution tomography (micro-CT) with a spatial resolution of 15.96-17.35 µm. Spatial resolution has improved continuously over time from 127 µm[20] to < 11 µm.[7] However an improvement in resolution is reflected by a long scanning time, which adds to an already long reconstruction period. Due to these considerations, sample size was set at 20 teeth. Despite variations in the morphology of extracted teeth, attempts were made to ensure standardization of experimental groups. Teeth in both BioRaCe and AlphaKite groups were balanced with respect to the angle of canal curvature based on initial radiographs.

The shaping ability of an instrument and its safe use depend on factors such as alloy type, taper and size of instrument, type of the cutting tip and geometry of the cross-section. Both systems used in the study are characterized by a non-cutting safety tip. The use of instruments with sharp cutting tips predisposes to transportation and creates defects during preparation.[2,21,22] BioRaCe instruments have sharp cutting edges with a triangular cross-section with no radial lands. Instruments with actively cutting blades display better results in terms of canal cleanliness than files with radial lands.[3,23] Active cutting edges seem to cut and remove both dentine and pulp remnants, whereas radial lands tend to burnish the cut dentine onto the root canal wall or even push debris inside dentinal tubules.[4]

Debris removal capability also determines the efficiency of rotary instruments because the removal of dentine debris is important to reduce clogging of the cutting blades.[24] The manufacturer of AlphaKite claims that the kite-shaped design with an active cutting angle and three more supporting blades provide large spaces that guarantee optimum debris removal from the root canal. At present, there is no published literature about the kite-shaped design feature. Schäfer & Oitzinger[25] reported that RaCe instruments had great debris removal capability and great space. It may be speculated that BioRaCe and AlphaKite instruments have comparable removal capability and at the same time large space that prevents apical blockage and, thus, result in minimal transportation.

The occurrence of deviations can, therefore, depend on factors other than curvature, such as instrument design, physical properties of the alloy and technical instrumentation.[8,26] Results show that the direction of transportation in the apical area is mainly related to the outer side of curvature. This finding is consistent with previous studies.[8,27,28] Pasternak-Junior et al,[29] however, reported transportation to the inner side of the curvature with the use of size 35 RaCe instruments with 0.02 taper. The authors reported the probable reason lies on the superelasticity of instruments, allowing them to follow canal curvature. This is in contrast to a previous study that showed that the inner wall of a canal in the apical portion received no or minimal preparation compared to the outer wall.[30] This can be explained by the use of early/first generation files that pioneered changes seen in a more recent generation of files, such as BioRaCe and AlphKite. Nevertheless, difference in transportation between both systems was not statistically significant at any level, while the degree of canal curvature did not seem to influence the results. It is debatable whether or not the small amount of transportation occurring in both systems is clinically relevant. The occurrence of apical transportation, however, is a factor that negatively influences the apical seal compared to ideally prepared canals.

Conclusion

In conclusion, within the limitations of this study, our results showed that BioRaCe and AlphaKite instruments promoted safe root canal preparation with minimal canal transportation and good centering ability, with no significant difference between systems. Root canal curvature did not seem to influence the results.

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